



# Revised Zero Net Energy (ZNE) Definition

*IEPR Workshop*  
*California Energy Commission*  
*July 20, 2011*



# Scope of Zero Net Energy (ZNE)

## Definitions Group

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- Memo to clarify Zero Net Energy definition
  - Not full group consensus
- Questions include:
  - How is energy valued for trade-offs between different sources (natural gas, propane and electricity) and trade-offs with on-site renewable generation?
    - *Site, source, TDV,*
  - What energy consumption is included?
    - *Building operation, T-24 regulated only, embedded, transportation energy etc.?*
  - What is on-site renewable energy
    - *PV, hydro, fuel cells, biomass, landfill gas?*
  - What is on-site?
    - *Building site, development site, utility grid etc?*
  - How does definition or policy address sites that do not have access to renewable energy?

# Format of Refined ZNE Definitions

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- ❑ Relatively simple and short definition of ZNE
- ❑ Policy complexity captured in definitions of each term of the ZNE definition
- ❑ Key challenge: How to keep common sense definition of ZNE intact and meaningful while being applicable to all buildings in the near future
- ❑ Key finding: Definition of ZNE and policy goals had to be addressed together.

# Existing ZNE Definition and Big Bold Energy Efficiency Strategy (BBEES) ZNE Policy

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## ❑ Big Bold Energy Efficiency Strategy (BBEES)

- 1. All new residential construction in California will be zero net energy by 2020;*
- 2. All new commercial construction in California will be zero net energy by 2030;*

## ❑ Zero Net Energy (ZNE) definition:

*The amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building.*

*A ZNE building may also consider embodied energy – the quantity of energy required to manufacture and supply to the point of use, the materials utilized for its building.*

# Revised Zero Net Energy Goals

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1. All new residential construction in California will be zero net energy *or equivalent to zero net energy* by 2020;
2. All new commercial construction in California will be zero net energy *or equivalent to zero net energy* by 2030;

- ❑ Equivalency allows goal to be applicable to all buildings – even those unable to produce all net energy needs on site.
- ❑ Equivalency builds on Title 24 concept of prescriptive standard and a performance calculation that results in equivalent energy consumption.
- ❑ Equivalency in original intent reflected by original BBEES existing buildings goal:

*“50 percent of existing buildings will be equivalent to zero net energy buildings by 2030 through achievement of deep levels of energy efficiency and clean distributed generation.”*

# Revised Definition of Zero Net Energy

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The *societal value of energy* consumed by the *building* over the course of a typical year is less than or equal to the societal value of the *on-site renewable energy* generated.

For a home or low-rise dwelling unit, ZNE is achieved by demonstrating a California Whole-House Home Energy Rating of zero or less

# Definitions of terms for ZNE

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- ❑ **Societal value of energy** - long-term projected cost of energy including cost of peak demand and other costs including projected costs for carbon emissions, e.g., the time dependent valuation (TDV) of energy.
- ❑ **Building.** The property “receiving development entitlements and building code permits.” A single building, or set of buildings, i.e. a housing development
- ❑ **On-site** - new construction: similar to the definition of building. Existing: located on the contiguous property under control of the building owner.
- ❑ **Renewable resources** - Photovoltaic-generated electricity, solar-thermal generated electricity, micro-hydro generated electricity and wind-generated electricity.

# Building energy usage the basis for ZNE

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- ZNE definition based upon building energy usage
  - i.e. does not include embedded energy in materials or water, or transportation energy (though these are important)
- Building energy usage includes plug loads
  - 54% of residential energy consumption
  - Indicates the importance of appliance standards – ZNE target not just a Title 24 issue
  - Rating tools must consider installed appliances or accurate defaults for appliance usage (see COMNET and HERS II)



# Definitions of terms for ZNE equivalent

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- Zero net energy equivalent A property that achieves the societal value of energy (TDV energy) equivalent of ZNE with consideration of off-site renewable resources, or other factors to be determined by California policy makers.
- *ZNE equivalent* becomes meaningful as code for the 2019 Title 24 energy code.
- In the meantime, the intermediate steps help inform the ZNE equivalent rule sets.
  - Methods of equivalency and verification etc of off-site renewables
  - Energy equivalency and enforcement issues in the reach codes that may migrate into the energy code (LCA, transportation etc.)



# Zero Net Energy Definitions Development

*Summary of  
ZNE Definitions Group  
Findings*



McHugh Energy Consultants

# Importance of ZNE Concept

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- ❑ Bold concept has reoriented what is possible
  - 50% EE savings regularly discussed as goal
  - Hundreds of zero or near zero buildings
- ❑ Readily understandable, easy to market
  - Zero is the new green
- ❑ Organizing Principle for Policy
  - Energy codes
  - EE Programs
  - Renewables policy
  - Legislation
- ❑ Other policies apply

# 4 BIG BOLD Energy Efficiency Strategies

## Commercial New Construction

- All new commercial construction in California will be zero net energy by 2030.

## Residential / Small Commercial HVAC

- Heating, Ventilation, and Air Conditioning (HVAC) industry will be reshaped



## Low- Income Energy Efficiency

- All eligible low-income homes will be energy-efficient by 2020



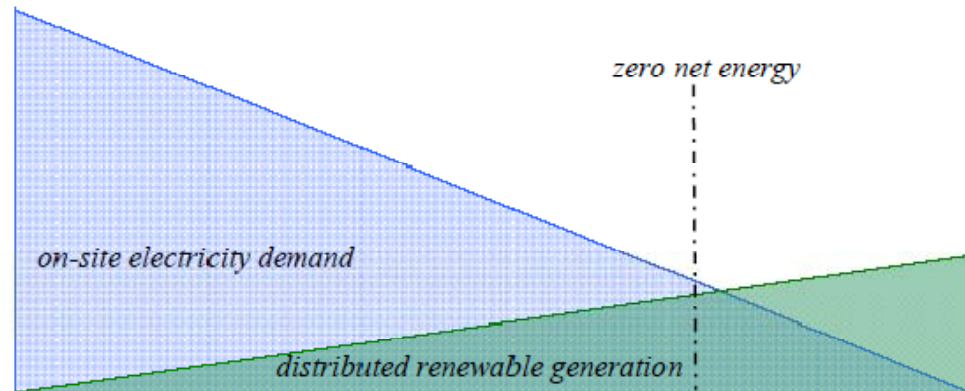
## Residential New Construction

- All new residential construction in California will be zero net energy by 2020.



# Half (2/4) of BBEES are Zero Net Energy (ZNE)

- 1. All new residential construction in California will be zero net energy by 2020;
- 2. All new commercial construction in California will be zero net energy by 2030;
  - Zero net energy is a general term applied to a building with a net energy consumption of zero over a typical year. To cope with fluctuations in demand, zero energy buildings are typically envisioned as connected to the grid, exporting electricity to the grid when there is a surplus, and drawing electricity when not enough electricity is being produced.

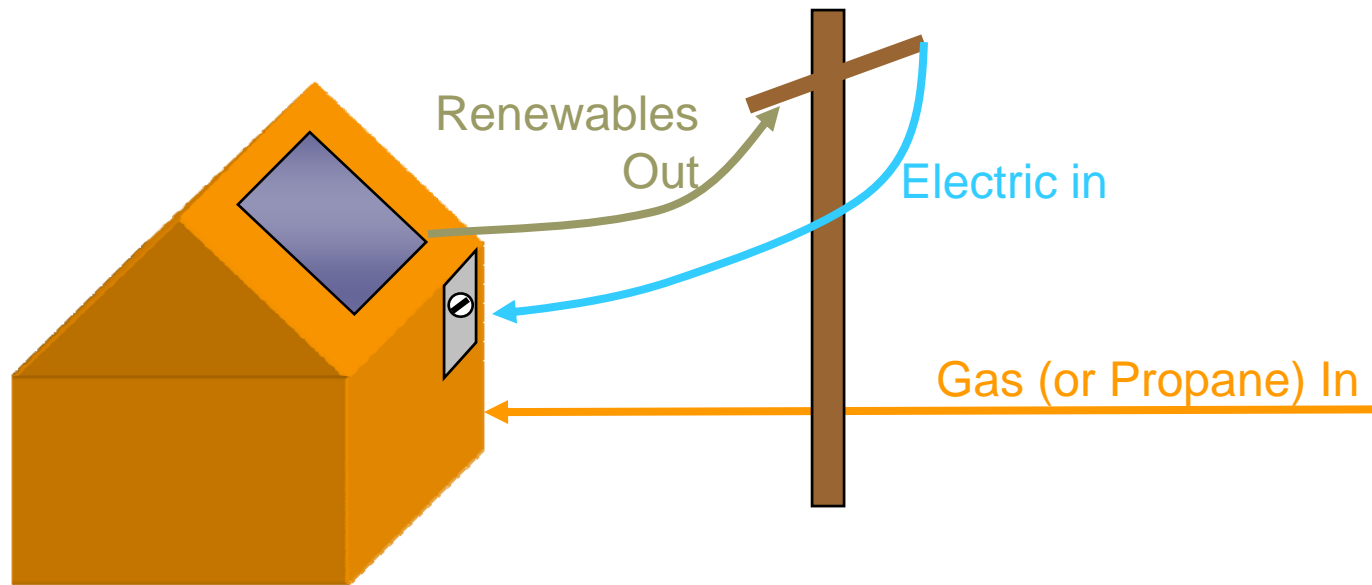


- The amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building.
- A ZNE building may also consider embodied energy – the quantity of energy required to manufacture and supply to the point of use, the materials utilized for its building
- The CPUC has defined “Zero Net Energy” at the level of a single “project” seeking development entitlements and building code permits ...



# What is net 0?

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- ❑ How are different sources valued?
- ❑ What is on-site?
- ❑ What is renewable?
- ❑ What if building site doesn't have access to renewable energy?

# Different Metrics for ZNE

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## □ Energy Trade-offs

- Site Energy
- Source Energy
- Societal Cost
  - *AKA TDV (time dependent valuation) Energy*
- Grid neutral
- Carbon neutral

## □ Choices on what to include

- Electricity only (see grid neutral)
- All sources of energy
- Building code regulated uses
  - *With or without plug loads, process uses*
- Embedded energy in water, building materials
- Transportation energy

# Site Energy (Customer Energy)

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## □ Pros

- Unequivocal definition
- Most stringent definition
- 100% renewable vision
  - *Future with 100% RPS*
- CPUC goals are in terms of site energy

## □ Cons

- In US different units for gas and electricity
- Harder/more costly to achieve goal (60% increase in renewable system size & cost)
- Treats Electricity, Propane and Natural Gas as having same value
- Ignores concept of thermodynamic quality
- Ignores societal energy consumption
  - *Encourage electric heating*
  - *At odds with current policy*
- Doesn't address peak demand



# Source Energy (Primary Energy)

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## □ Pros

- Consistency with other ZNE definitions
- Used by others (US, EU)
- Values Electricity and Fuels based on primary energy
- Recognizes thermodynamic quality
- Encourages fuel use for heating applications
- Easier to achieve goal
- Relatively easy to calculate once source multipliers are known

## □ Cons

- Source energy multipliers not consistent (varies by country, or utility)
- Source energy multiplier can be complex to calculate or over simplified
- Treats Propane and Natural Gas the same
- Doesn't address peak demand

# Societal Cost (TDV Energy)

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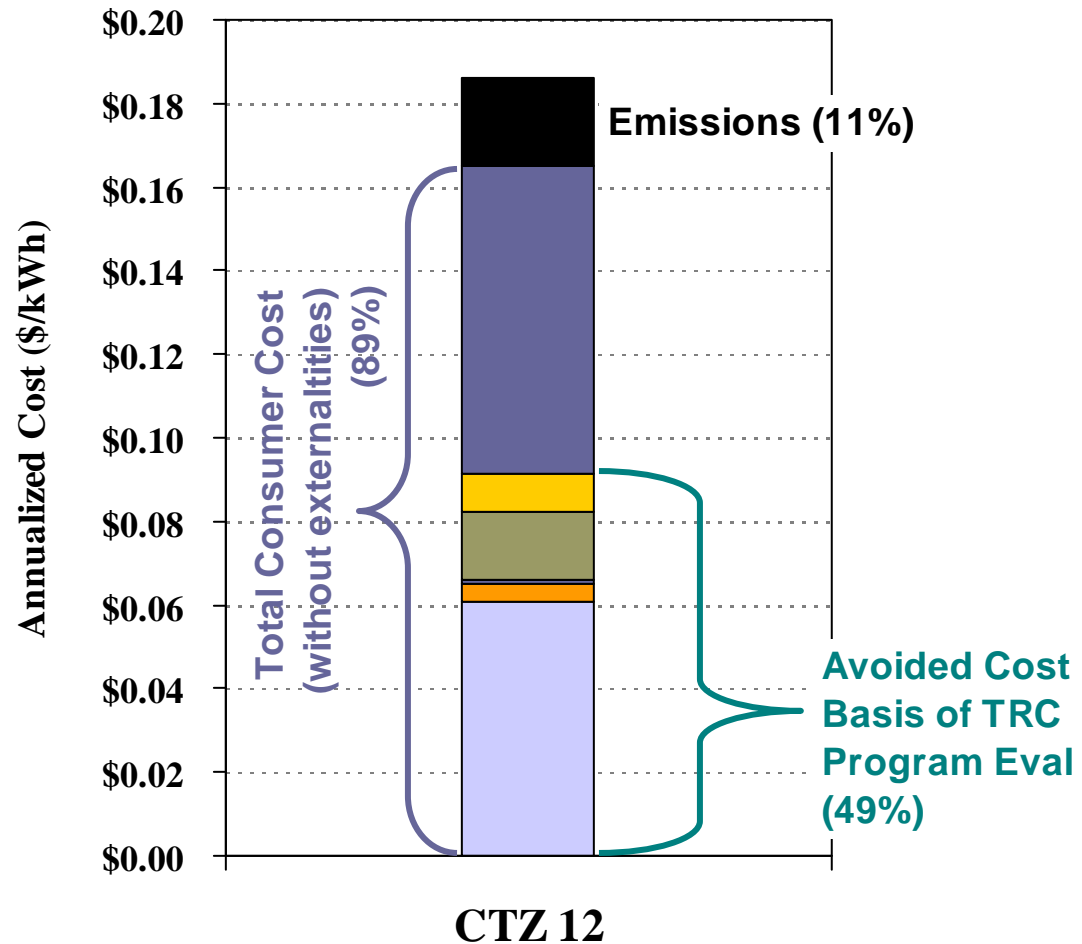
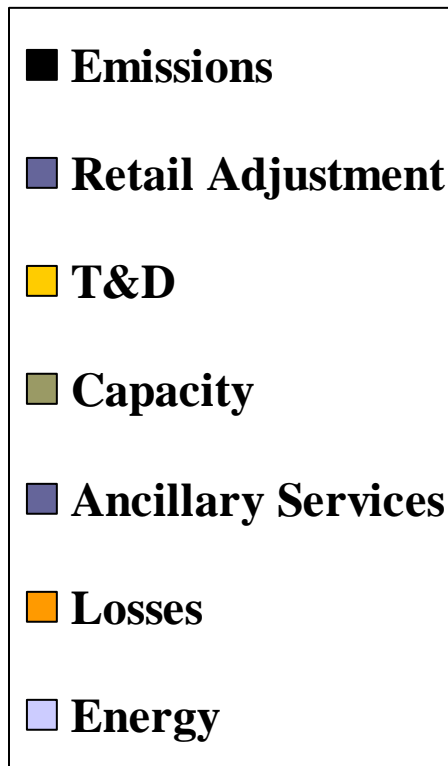
## □ Pros

- Benefits of source energy plus...
- Compatible with Title 24 performance trade-off calcs
- Compatible with Whole House Home Energy Rating (HERS)
- Accounts for value of:
  - *Different energy sources*
  - *Variable heat rate*
  - *Peak demand*
  - *Carbon*
- Relatively easy to add other policy decisions
  - *Value of water*
  - *Transportation*
- CPUC program evaluation based on similar metric (TDV minus retail rate adder)

## □ Cons

- TDV Not easy to market
  - *Societal Cost easier to explain*
- Complex to calculate
  - *Hourly basis*
  - *“Under the hood” of software*
  - *Complex billing analysis*
- Not purely energy
  - *Demand is equipment capacity cost*

# Components of TDV



Close approximation of consumer cost with approximately 10% added for emissions

# Grid neutral (electricity only)

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## □ Pros

- Avoids site/source issue
- Reflects previous CPUC policy
  - *Net metering did not give credit for being a net generator*
- Try to zero out electricity bill
- Easier to achieve

## □ Cons

- Doesn't match zero energy concept
  - *Fuels not included*
- No incentive to decrease heating loads
- Inappropriate fuel switching
- Doesn't address peak demand

# Carbon neutral

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## □ Pros

- Reflects AB 32 goals
- Addresses all fuels
- Popular concept

## □ Cons

- Doesn't reflect other goals
- Doesn't reflect full costs or impacts of many low carbon technologies
- Peak demand not addressed

# T-24 regulated loads only

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## □ Pros

- Easier to calculate
  - *Don't have to estimate what appliances installed and their usage*
- Enforceable through building code
- Sets bar lower
  - *Easier to achieve*

## □ Cons

- Doesn't reflect basic idea of ZNE
- Wouldn't cover over half of electric loads
- Fall short of meeting all building loads
- All loads are estimated from model of behavior and quality of installation
- Would distort policy
  - *i.e. not important to capture appliance efficiency*

# Importance of 2020 achievable goal

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- ❑ If bar set too high goal becomes "aspirational" (i.e. non-goal)
- ❑ EU - "near net zero" by 2020
- ❑ Repercussions of leaving out transportation, embedded energy etc.
- ❑ Impact of non-T-24-regulated loads high (basis of assumed unregulated loads)
- ❑ Rationale for leaving plug loads in the model (i.e. matches common sense understanding of ZNE)
- ❑ See following slides on impact of different definitions.

# Residential Electricity and Natural Gas Consumption Impacted by Title 24 (Weighted Consumption from 2009 RASS\*)

## Electricity End-uses

End-Use kWh/yr

<b>Not covered by T-24</b>	<b>3,612</b>	
Dryer	187	
Clothes Washer	109	
Dish Washer	73	
First Refrigerator	707	
Additional Refrigerator	313	
Freezer	138	
Range/Oven	105	
Television	645	
Microwave	122	
Home Office Equipment	17	
Personal Computer	602	
Well Pump	28	
Miscellaneous	568	
<b>T-24 + Preempted</b>	<b>1,106</b>	
Conv. Space Heating	37	
Heating	13	
Aux Space Heating	0	
Central Air Conditioning	876	
Room Air Conditioning	47	
Water Heating	133	
<b>T-24</b>	<b>1,927</b>	
Furnace Fan	164	
Attic Fan	14	
Evaporative Cooling	43	
Solar Water Heating	0	
Pool Pump	234	
Spa	25	
Outdoor Lighting	284	
Spa Electric Heat	28	
Lighting	1,136	
<b>Total</b>	<b>6,645</b>	

54%

10%

29%

Over half of home electricity consumption not covered by T-24

## Natural Gas End-uses

End-Use Therm/yr %

<b>Not Covered by T-24</b>	<b>51.4</b>	
Dryer	16.2	
Range/Oven	31.7	
Miscellaneous	3.5	
<b>T-24+ preempted</b>	<b>309.0</b>	
Primary Heat	175.8	
Conv. Gas Water Heat	133.2	
<b>T-24</b>	<b>10.2</b>	
Pool Heat	5.6	
Spa Heat	2.9	
Auxiliary Heat	1.6	

14%

83%

3%

**Total 370.5**

### Not Covered by T-24

Plug loads are installed after building inspection and are not covered by T-24

### T-24 + Preempted

T-24 is preempted from requiring higher equipment efficiency but T-24 can impact the loads on equipment (envelope eff, controls etc.)

### Covered by T-24

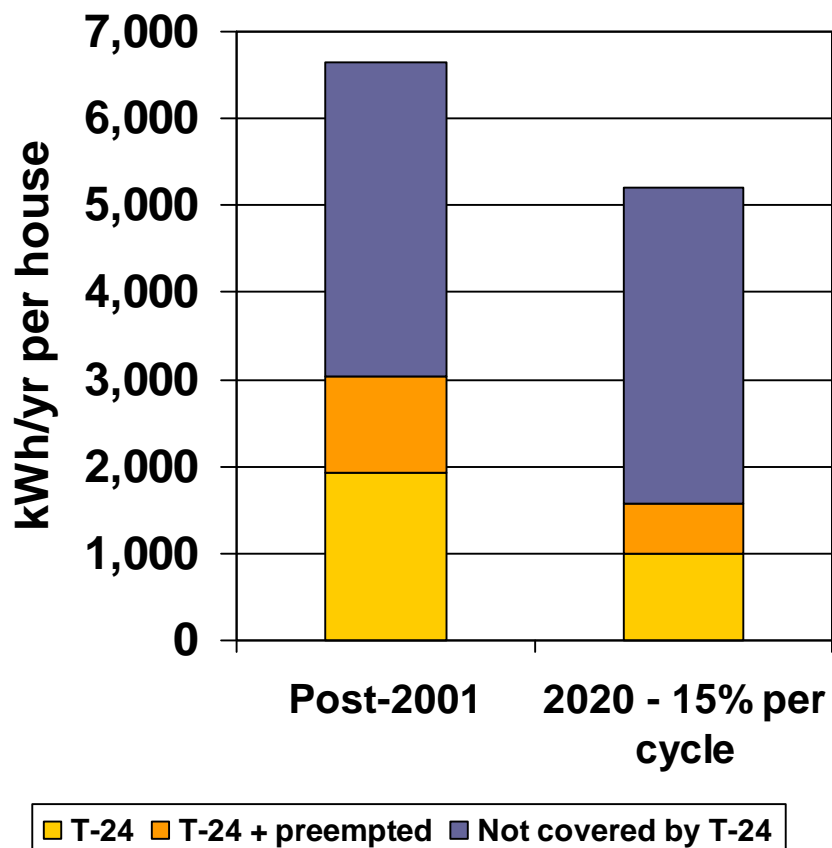
Loads and equipment efficiency can be regulated by T-24

\* Residential Appliance Saturation Survey

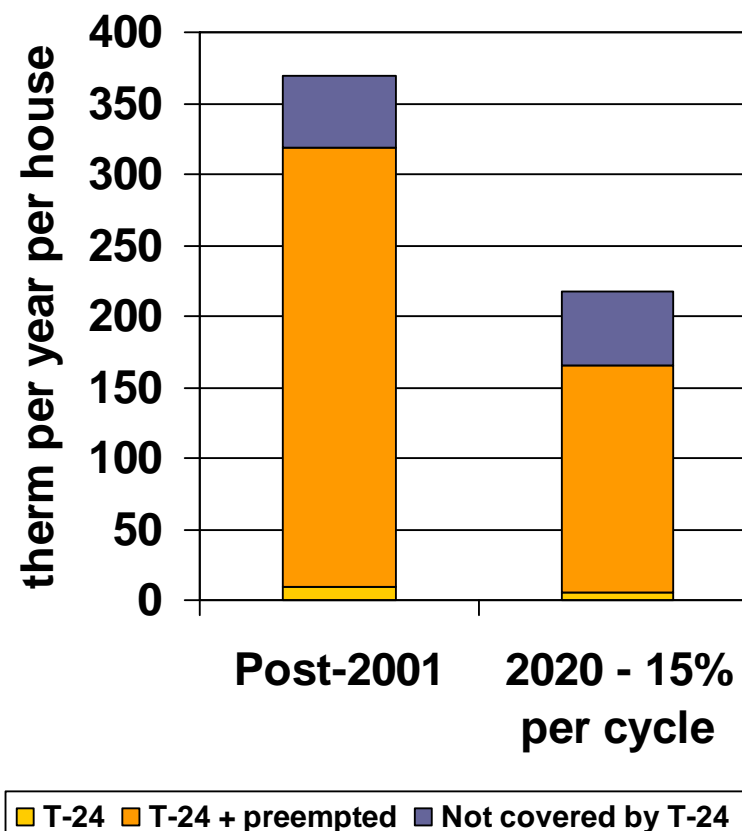


# RASS 2009 New Single Family (built after 2001) assuming all T-24 loads (including preempted) reduced 15% per cycle over 4 cycles

## Electricity Consumption



## Natural Gas Consumption



$$15\% \text{ reduction after 4 cycles} = 0.85^4 = 0.52$$

# Amount of PV required for different scenarios (high PV cost)

Investment in PV more than twice as high if efficiency limited to 15% reductions in T-24 covered energy per cycle than 2/3's total reduction

Two scenarios for 2020

Current new buildings	PV kWh	PV kW	PV Cost \$/house	First Cost \$ Million/yr
Site energy ZNE	17,501	11.7	\$81,669	\$8,167
Source energy ZNE	10,264	6.8	\$47,896	\$4,790
(Elec) Grid neutral	6,645	4.4	\$31,010	\$3,101

48% reduction T-24 (4 cycles 15% reduction)	PV kWh	PV kW	PV Cost \$/house	First Cost \$ Million/yr
Site energy ZNE	11,581	7.7	\$54,047	\$5,405
Source energy ZNE	7,324	4.9	\$34,179	\$3,418
(Elec) Grid neutral	5,195	3.5	\$24,245	\$2,425

66% reduction all end-uses	PV kWh	PV kW	PV Cost \$/house	First Cost \$ Million/yr
Site energy ZNE	5,834	3.9	\$27,223	\$2,722
Source energy ZNE	3,421	2.3	\$15,965	\$1,597
(Elec) Grid neutral	2,215	1.5	\$10,337	\$1,034

Assumes: 1,500 kWh/yr per nominal kW, \$7/Watt installed cost (modest cost reduction), 100,000 homes built per year

LBNL reported residential installed PV costs of \$7.90/W in 2009 <http://eetd.lbl.gov/ea/emp/reports/lbnl-4121e.pdf>

# Amount of PV required for different scenarios (low PV cost)

Investment in PV more than twice as high if efficiency limited to 15% reductions in T-24 covered energy per cycle than 2/3's total reduction

Two scenarios for 2020

Current new buildings	PV kWh	PV kW	PV Cost \$/house	First Cost \$ Million/yr
Site energy ZNE	17,501	11.7	\$52,502	\$5,250
Source energy ZNE	10,264	6.8	\$30,791	\$3,079
(Elec) Grid neutral	6,645	4.4	\$19,935	\$1,994

48% reduction T-24 (4 cycles 15% reduction)	PV kWh	PV kW	PV Cost \$/house	First Cost \$ Million/yr
Site energy ZNE	11,581	7.7	\$34,744	\$3,474
Source energy ZNE	7,324	4.9	\$21,972	\$2,197
(Elec) Grid neutral	5,195	3.5	\$15,586	\$1,559

66% reduction all end-uses	PV kWh	PV kW	PV Cost \$/house	First Cost \$ Million/yr
Site energy ZNE	5,834	3.9	\$17,501	\$1,750
Source energy ZNE	3,421	2.3	\$10,264	\$1,026
(Elec) Grid neutral	2,215	1.5	\$6,645	\$665

**Assumes: 1,500 kWh/yr per nominal kW, \$4.50/Watt installed cost (developed market for PV), 100,000 homes built per year**

\$4.50/Watt installed in 2009 in Germany (more developed market) <http://eetd.lbl.gov/ea/emp/reports/lbnl-4121e.pdf>

# What is on-site renewable energy?

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- On-site – first start with CPUC definition:
  - “...single “project” seeking development entitlements and building code permits ...”
  - Final implementation avenue (2020 and 2030 goals) through building codes.
  - Allows onsite renewables on carports, common areas, club houses, ground mounted on same development site etc.
- On-site renewable energy (only electricity exported)
  - Photovoltaic
  - Small hydro
  - Solar thermal electricity
  - Wind generated electricity
  - Does **not** include: biomass, landfill gas, fuel cells,
    - *no imports of fuel to serve device and no on-site emissions*

# What if I have no site access to renewable energy?

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- ❑ Earlier definitions – attempt to broaden definition to account for all cases where ZNE not feasible
  - High rise, shaded site with no wind etc.
- ❑ Ultimately all exceptions weakened concept of what ZNE was.
- ❑ Rather than redefine ZNE so that it was possible to meet policy goal of all buildings being ZNE, redefine policy goals:
  1. All new residential construction in California will be zero net energy or equivalent to zero net energy by 2020;
  2. All new commercial construction in California will be zero net energy or equivalent to zero net energy by 2030;

# Redefining 2020 target in terms of ZNE equivalence

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- ❑ *All new residential construction in California will be zero net energy or equivalent to zero net energy by 2020*
- ❑ With goal being ZNE equivalence don't have to dilute the common sense (and marketable) meaning of ZNE
- ❑ Addresses all of the applications where ZNE not feasible: obstructions, trees, high rise buildings

# Acknowledgements

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- I would like to thank the members of the ZNE Definitions Team:
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- I would also like thank the group facilitators: Rick Diamond and Brenda Hopewell
- McHugh Energy would like to acknowledge the support received from the Energy Foundation and the Statewide IOU Codes & Standards program



# Supporting Slides

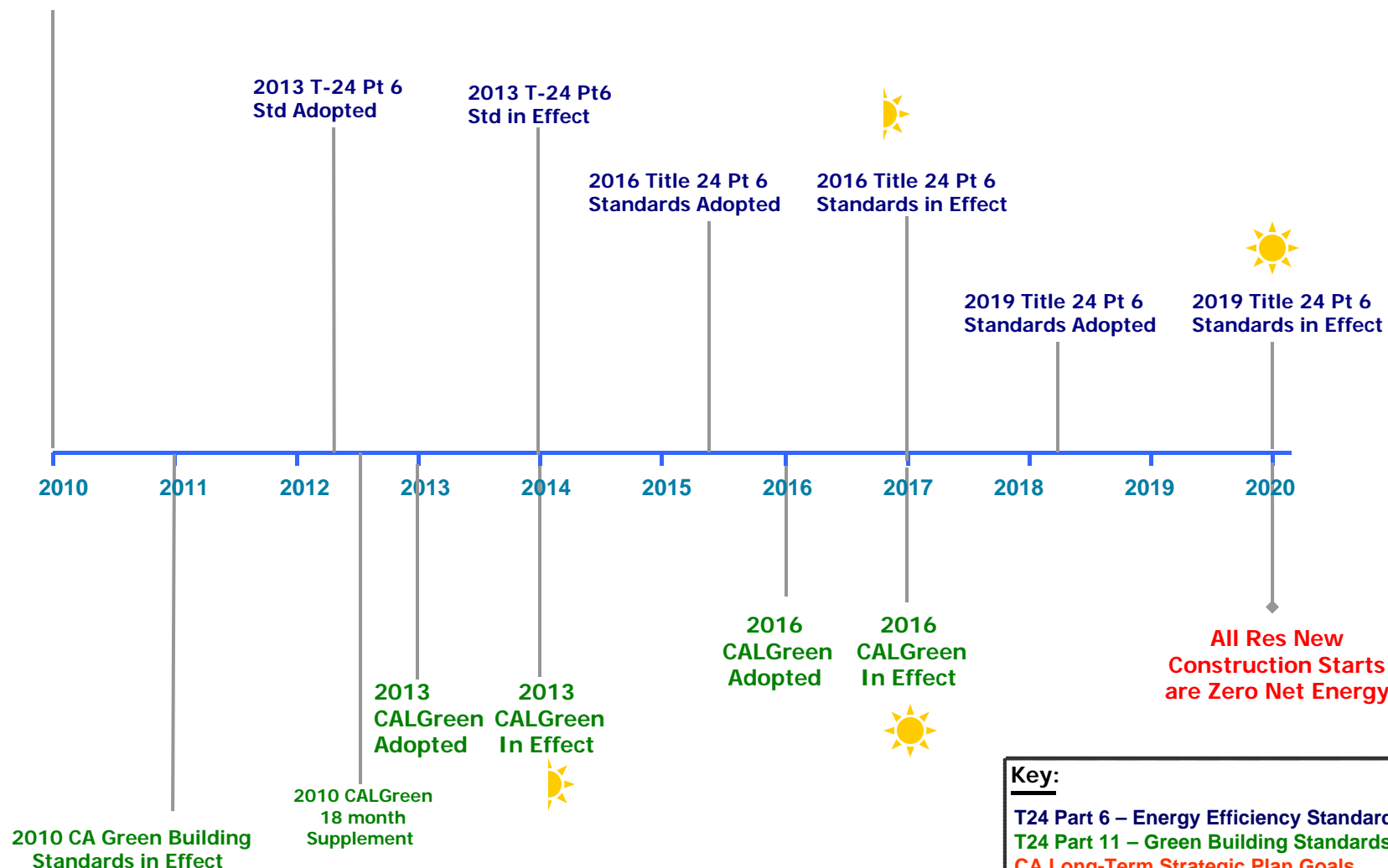
## Strategic Next Steps





# Title 24 Path to Net Zero - Residential

2008 Title 24 part 6  
Standards in Effect



**Key:**

T24 Part 6 – Energy Efficiency Standards

T24 Part 11 – Green Building Standards

CA Long-Term Strategic Plan Goals

 On-site renewables in base case

# Residential Building Standards

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## □ Zero Net Energy is organizing principle

- Basis of CPUC policy – EE Strategic Plan
- Basis of CEC Policy – IEPR
- Reduce energy consumption though efficiency first
  - *Implement all efficiency that is cheaper than future cost of PV*
- Serve remaining load with on-site renewables
  - *Remove barriers to PV (cost is 35% cheaper in Germany)*

## □ Goals by Code Cycle

- “All new residential construction in California will be zero net energy by 2020”  
CPUC Energy Efficiency Strategic Plan.
  - *2019: Title 24 requires renewables and ZNE in all new homes*
  - *2016: prepare market by including renewable requirement in ACM.*
  - *2013: opportunity to place solar thermal and PV into ACM*

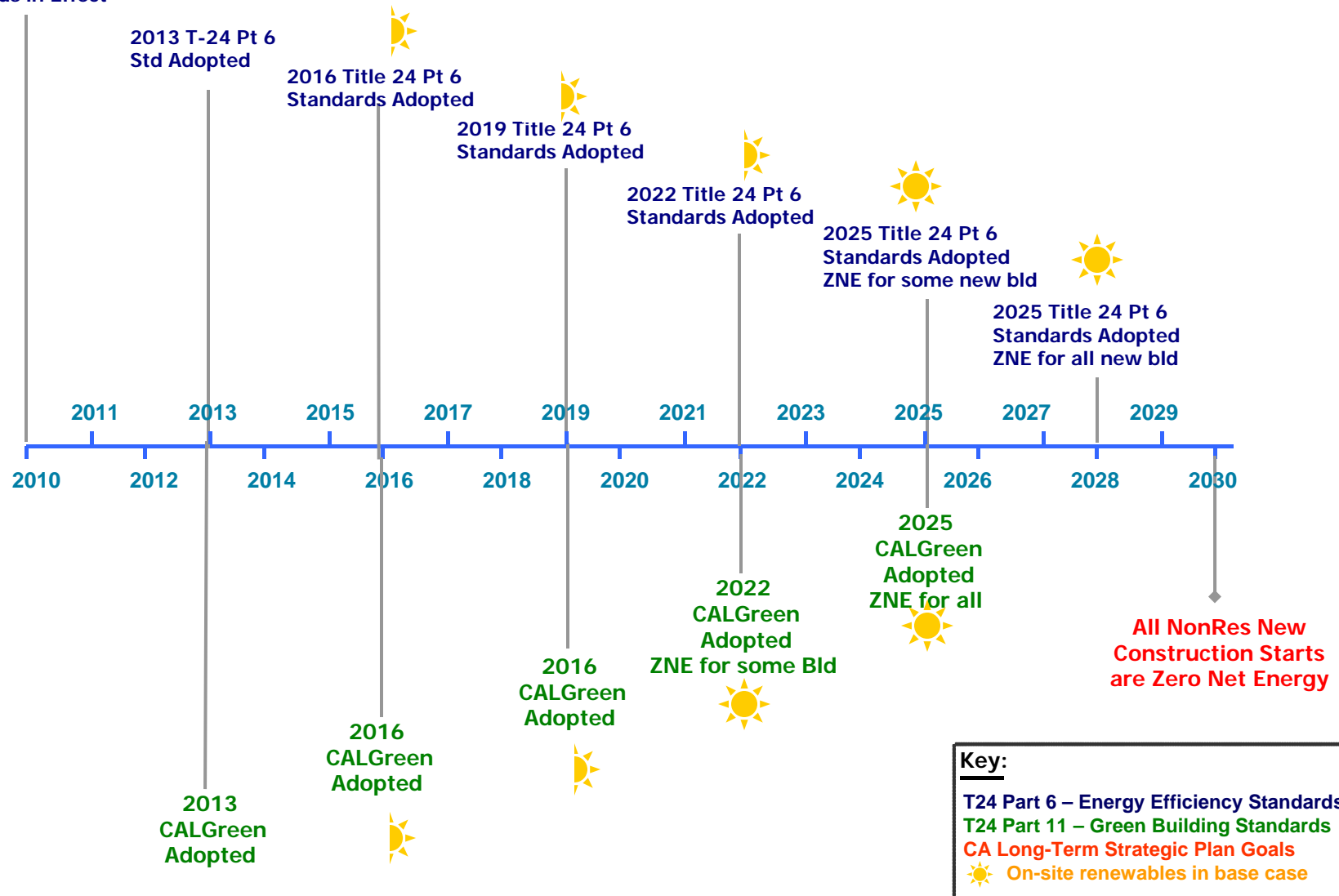
# Residential Reach Codes

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- ❑ Local ordinances (reach codes) prepare the market in advance of statewide standards.
- ❑ CALGreen voluntary tiers intended for local government adoption
  - ❑ *Tier 1 is one code cycle in advance of Title 24, Part 6*
    - 2016 CALGreen Tier 1 should be ZNE
  - ❑ *Tier 2 is two cycles in advance of Title 24, Part 6*
    - 2013 CALGreen Tier 2 should be ZNE
- ❑ Diversity of approaches depending on local market requirements and conditions
  - ❑ *Opportunity to learn from leading cities which approach works well for different market sectors and geographic regions*

# Title 24 Path to Net Zero – Nonresidential Building Standards

2008 Title 24 part 6 Standards in Effect



# What things need to happen this code cycle?

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- ❑ Start allowing PV trade-offs (max kBtu cap, window area trade-off etc)
- ❑ Join other states (WA, OR) that are using dual path in lieu of preemption waiver
- ❑ Reach Codes (CALGreen) get market ready for future:
  - Residential Tier 2 is ZNE,
  - Residential Tier 1 best estimate of 2016 Title 24

# Which tools must calculate ZNE?

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- ❑ What trade-offs are allowed with on-site renewables?
- ❑ Performance software
- ❑ HERS II rating
- ❑ Billing analysis (interval meters)

# Nonresidential Building Standards

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- ❑ Policy - All new nonresidential buildings will be ZNE by 2030
- ❑ Some buildings easier to hit ZNE target
  - ❑ *Low rise – more roof area per sf of conditioned floor area*
  - ❑ *Low energy intensity (i.e. warehouses, schools)*
- ❑ Possibly stage timing of ZNE requirements by building type
  - ❑ *First demonstrate with gov't buildings and motivated owners*
  - ❑ *Low intensity buildings earlier than high intensity*
- ❑ ZNE residential will help prepare market
  - ❑ *Appliance standards more important than res (plug loads, lighting)*
- ❑ Scope of nonresidential codes will increase
  - ❑ *More process and plug loads*
  - ❑ *More building categories with energy standards (hospital, institutional)*
- ❑ Requires improved modeling tools for advanced technologies
  - ❑ *Radiant and evaporative cooling, displacement and natural ventilation*

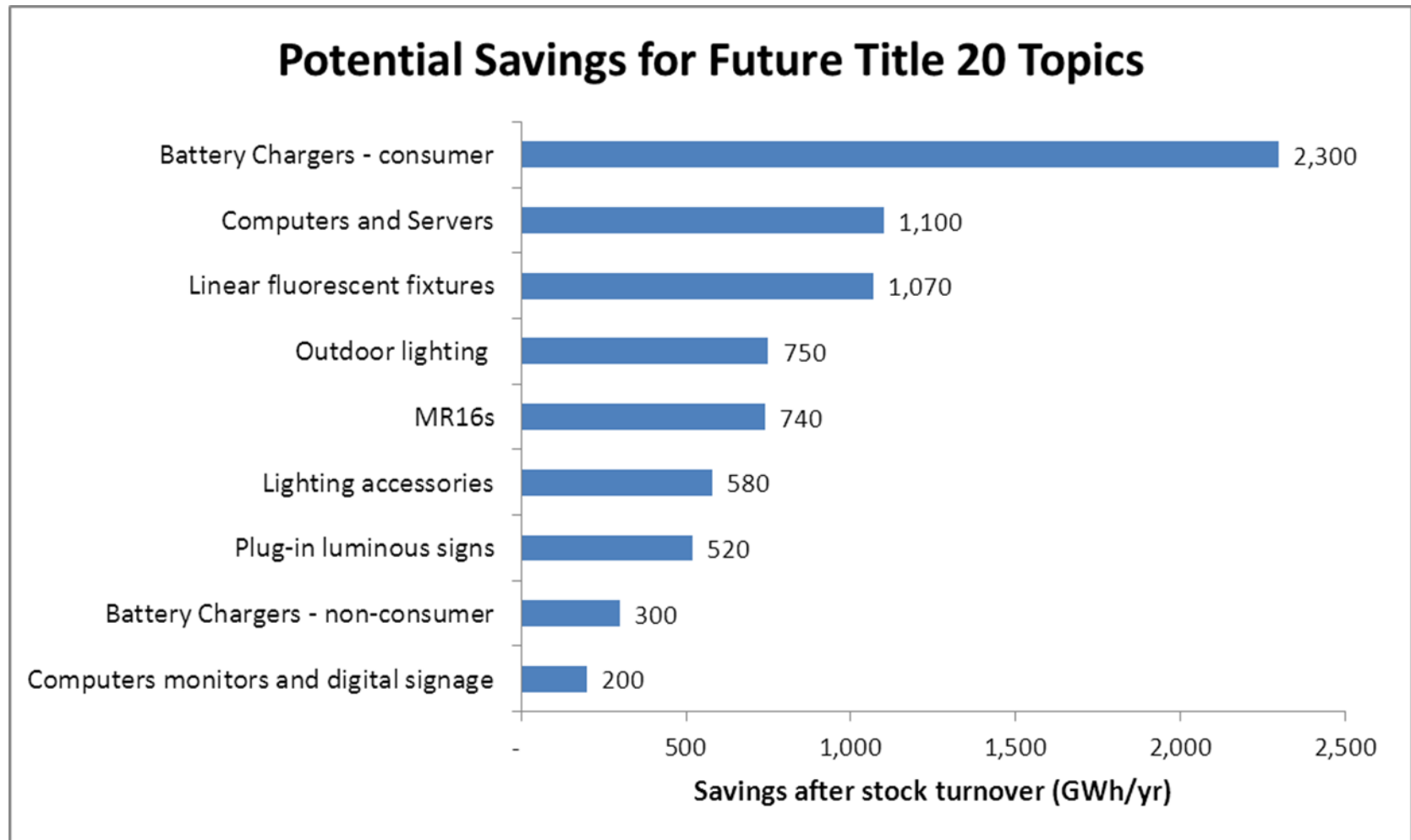
# CA Title 20 Appliance Standards

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- Aggressive appliance standards required to hit residential ZNE goals
- Over half of home electricity consumption is for appliances not covered by Title 24 (white goods + consumer electronics)
- Appliance standards impact existing building energy consumption
  - Approximately 2% of new construction per year.
    - *80% of buildings in 2020 are standing now*
    - *Buildings last 50+ years*
    - *Appliances turn over much more quickly*
- Huge potential energy savings opportunity



# Potential Savings from Future Title 20 Topics



Note: All savings are current estimates and subject to change upon further standard development research. Source: Energy Solutions

# Federal Appliance Standards

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- Large fraction of energy consumption in federally regulated appliances
  - 80% of res gas consumption in fed preempted DHW and furnaces.
    - *Elevates importance of preemption & participation in fed standards*
- Substantial peak impacts associated with fed covered equipment
  - Air conditioners
- Preemption must be addressed long term
  - Federal standards should be floor not ceiling for efficiency
  - Federal regulation more regionally based (climate, energy costs)
  - Blanket waiver or legislation
- Easier to enforce than state appliance standard
  - International commerce renders enforcement more difficult at state level
    - *Coordination with international suppliers*

# Policy overlaps and divergence

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Policies	CEC	CPUC	CARB	CALISO	Fed
Preemption of State Efficiency Standards					
Increasing stringency and expanding scope of building codes					
Increasing stringency and expanding scope of appliance standards					
Expansion of Renewable Energy					